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NATIONAL BUREAU OF STANDARDS REPORT

8165

PERFORMANCE TEST OF A "DUSTFOE" DEEP-BED DISPOSABLE AIR FILTER, MODEL G-1000

manufactured by
Mine Safety Appliances Company
Pittsburgh, Pennsylvania

by

Joseph C. Davis and Paul R. Achenbach

Report to

General Services Administration
Public Buildings Service
Washington 25, D. C.

NBS

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

U. S. DEPARTMENT OF COMMERCE
Luther H. Hodges, *Secretary*

NATIONAL BUREAU OF STANDARDS
A. V. Astin, *Director*

THE NATIONAL BUREAU OF STANDARDS

Functions and Activities

The functions of the National Bureau of Standards include the development and maintenance of the national standards of measurement and the provision of means and methods for making measurements consistent with these standards; the determination of physical constants and properties of materials; the development of methods and instruments for testing materials, devices, and structures; advisory services to government agencies on scientific and technical problems; invention and development of devices to serve special needs of the Government; and the development of standard practices, codes, and specifications, including assistance to industry, business, and consumers in the development and acceptance of commercial standards and simplified trade practice recommendations. The work includes basic and applied research, development, engineering, instrumentation, testing, evaluation, calibration services, and various consultation and information services. Research projects are also performed for other government agencies when the work relates to and supplements the basic program of the Bureau or when the Bureau's unique competence is required. The scope of activities is suggested by the listing of divisions and sections on the inside of the back cover.

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The results of the Bureau's research are published either in the Bureau's own series of publications or in the journals of professional and scientific societies. The Bureau itself publishes three periodicals available from the Government Printing Office: The Journal of Research, published in four separate sections, presents complete scientific and technical papers; the Technical News Bulletin presents summary and preliminary reports on work in progress; and Central Radio Propagation Laboratory Ionospheric Predictions provides data for determining the best frequencies to use for radio communications throughout the world. There are also seven series of nonperiodical publications: Monographs, Applied Mathematics Series, Handbooks, Miscellaneous Publications, Technical Notes, Commercial Standards, and Simplified Practice Recommendations.

A complete listing of the Bureau's publications can be found in National Bureau of Standards Circular 460, Publications of the National Bureau of Standards, 1901 to June 1947 ($1.25), and the Supplement to National Bureau of Standards Circular 460, July 1947 to June 1957 ($1.50), and Miscellaneous Publication 240, July 1957 to June 1960 (includes Titles of Papers Published in Outside Journals 1950 to 1959) ($2.25); available from the Superintendent of Documents, Government Printing Office, Washington, D.C., 20402.

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NBS PROJECT | **NBS REPORT**

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DISPOSABLE AIR FILTER, MODEL G-1000

manufactured by
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Pittsburgh, Pennsylvania

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Joseph C. Davis and Paul R. Achenbach
Mechanical Systems Section
Building Research Division

to

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1. Introduction

At the request of the Public Building Services, the performance characteristics of a "Dustfoe", Model G-1000, disposable deep-bed air filter manufactured by the Mine Safety Appliances Company of Pittsburgh, Pennsylvania, were determined. The scope of the investigations included the determination of the arrestance of the particulate matter in the laboratory air and of Cottrell precipitate by the filter, and the pressure drop of the filter at the rated air flow of 1000 cfm as the dust load was progressively increased from zero to a final value corresponding to a pressure drop of 1.0 in. W.G.

2. Description of Test Specimen

The filter was manufactured and supplied for test purposes by the Mine Safety Appliances Company of Pittsburgh, Pennsylvania. It was identified as "Dustfoe", Model G-1000. The outside dimensions of the filter unit were 23 1/2" x 23 1/2" x 6". Four pieces of 1/8" cement-asbestos board 23 1/2"x 6", with galvanized metal angles front and back formed a rigid box frame. The filter media area was approximately 112 ft^2 and consisted of a glass fiber mat. The filter media was folded into 70 pleats, 5 inches deep, and was supported on separators of corrugated aluminum 5 1/2 inches wide with 3/8 inch corrugations. The gross face area of the filter unit was 3.84 ft^2, but the enclosing edges of the metal frames reduced the net face dimensions to 22 1/2" by 22 1/2" and the net face area to 3.52 ft^2.

At the rated air flow of 1000 cfm the net face velocity was 284 ft/min and the average air velocity through the filter media was about 9 ft/min. The weight of the clean filter was about 5,610 grams or 12.4 lb.

3. Test Method and Procedure

The filter was tested at the rated air flow of 1000 cfm. The arrestance determinations were made with the NBS Dust Spot Method described in a paper by R. S. Dill entitled "A Test Method For Air Filters" (ASHVE Transactions, Vol. 44, p. 379, 1938). The filter under test was installed in the test apparatus and carefully sealed to prevent any by-pass of air or inward flow into the test apparatus, except through the measuring orifice. After establishing the correct air flow rate through the filter, samples of air were drawn from the center points of the test duct 2 feet upstream and 8 feet downstream of the test specimen at equal rates and passed through known areas of Whatman No. 41 filter paper. Arrestance determinations were made using the particulate matter in the laboratory air as the aerosol and also with Cottrell precipitate injected into the air stream at a ratio of 1 gram per 1000 cu. ft. of air.

The light transmission of the sampling papers was measured before and after the test and the two sampling papers used for any one arrestance determination were selected to have the same light transmission when clean.

For determining the arrestance of the particulate matter in the laboratory air, equal sampling areas were used in the upstream and downstream samplers. A similar increase of the opacity of the two sampling papers was obtained by passing the sampling air through the upstream paper only part of the time while operating the downstream sampler continuously. This time proportioning was accomplished with the use of one solenoid valve in the upstream sampling line and another in a line by-passing the sampler. The solenoid valves were operated by an electric timer and a relay so that one was open while the other one was closed during any desired percentage of the 5-minute timer cycle, reversing the position of the two valves during the remainder of the cycle. The arrestance, A, (in percent), was then determined with the formula:

$$A = 100 - T \times \frac{\Delta D}{\Delta U}$$

where T is the percentage of time during which air was drawn through the upstream sampler, and ΔU and ΔD are the observed changes in the opacity of the upstream and downstream sampling papers, respectively. For each level of filter loading, two determinations were made. The value of arrestance reported in each case was the average obtained from the two determinations.

For determining the arrestance of the filter with Cottrell precipitate as the test dust, different size areas of sampling paper were used upstream and downstream of the filter in order to obtain a similar increase of opacity on both sampling papers. The arrestance was then calculated by the formula:

$$A = 1 - \frac{S_D}{S_U} \times \frac{\Delta D}{\Delta U} \times 100$$

where the symbols A, ΔU and ΔD are defined the same as indicated above and S_U and S_D are the upstream and downstream sampling areas, respectively.

Both types of arrestance determinations were made at the beginning and at the end of the test and at several intermediate loading conditions. The loading was done incrementally, each increment consisting of 96 parts Cottrell precipitate and 4 parts of cotton linters, by weight. The Cottrell precipitate had been previously sifted through a 100-mesh screen and the lint was prepared by grinding No. 7 cotton linters through a Wiley mill with a 4-millimeter screen.

The pressure drop across the filter under test was recorded at the beginning of the test, after each arrestance determination, and after each increment of Cottrell precipitate and lint that was introduced into the test duct. The test was terminated when the pressure drop across the filter reached 1.0 in. W.G.

At the rated air flow of 1000 cfm, a small fraction of the Cottrell precipitate and lint dropped out of the air upstream from the filter during the test. The total amount of fallout was determined as 80 grams at the conclusion of the test, and the amount of loading for each incremental determination was adjusted proportionally to the size of the increment.

Upon completion of the test on the first filter specimen a test without loading on the filter media was performed on another specimen supplied by the manufacturer. For this test, an arrestance determination was made using only the laboratory air as the aerosol. The pressure drop across the filter was also observed under these conditions.

4. Test Results

The test results obtained on the two air filter specimens at an air flow rate of 1000 cfm are summarized in Table 1. The dust loads shown in this table are the weights of Cottrell precipitate and lint introduced into the test apparatus diminished by the percentage of dust fallout upstream of the filter.

It will be noted that the pressure drop increased from 0.174 in. W. G. with a clean filter to 1.034 in. W. G. after a dust load of 1730 grams had reached the filter.

The arrestance of the dust in the atmospheric air increased from 36.2 percent to 86.1 percent during the loading period and averaged approximately 63.7 percent. The dust load of Cottrell precipitate and lint corresponding to a pressure drop of 1.0 in. W.G. was 491 grams/ft^2 of net face area and about 15.5 grams/ft^2 of filter media. The arrestance values determined with Cottrell precipitate increased from an initial value of 93.8 percent to a final value of 98.6 percent.

The values shown in Table 1 are graphically presented in Figure 1. In this figure the arrestance of particulate matter in the laboratory air, the arrestance for the Cottrell precipitate and the pressure are all plotted against the dust load.

The initial pressure drop and arrestances of the two filter specimens were essentially identical.

Table 1

Performance of Mine Safety Appliances Company "Dustfoe" Disposable Air Filters, G-1000, At An Air Flow Rate of 1000 CFM

Dust Fed: Cottrell Precipitate Grams	Dust Fed: Lint Grams	Cumulative Load[A] Grams	Arrestance of Aerosol Percent: Atmospheric[B]	Arrestance of Aerosol Percent: Cottrell[C]	Pressure Drop in. W.G.
0	0	0	36.2	93.8	.174
140	5.6	139	42.6	-	.193
320	12.8	318	46.5	95.5	.215
520	20.8	517	51.1	97.1	.249
840	33.6	835	60.6	98.3	.335
1040	41.6	1034	72.0	98.6	.414
1340	53.6	1332	82.6	98.5	.610
1560	62.4	1541	85.7	99.1	.818
1740	69.6	1730	86.1	98.6	1.034
		Second Filter			
0	0	0	37.0	-	.178

A - Corrected for fallout

B - Atmospheric-Aerosol is the particulate matter in the laboratory air

C - Cottrell-Aerosol is Cottrell precipitate in laboratory air

PERFORMANCE CURVES FOR MINE SAFFTY
APPLIANCES "DUSTFOE" MODEL G-1000
DISPOSABLE AIR FILTER
AIR FLOW RATE 1000 CFM

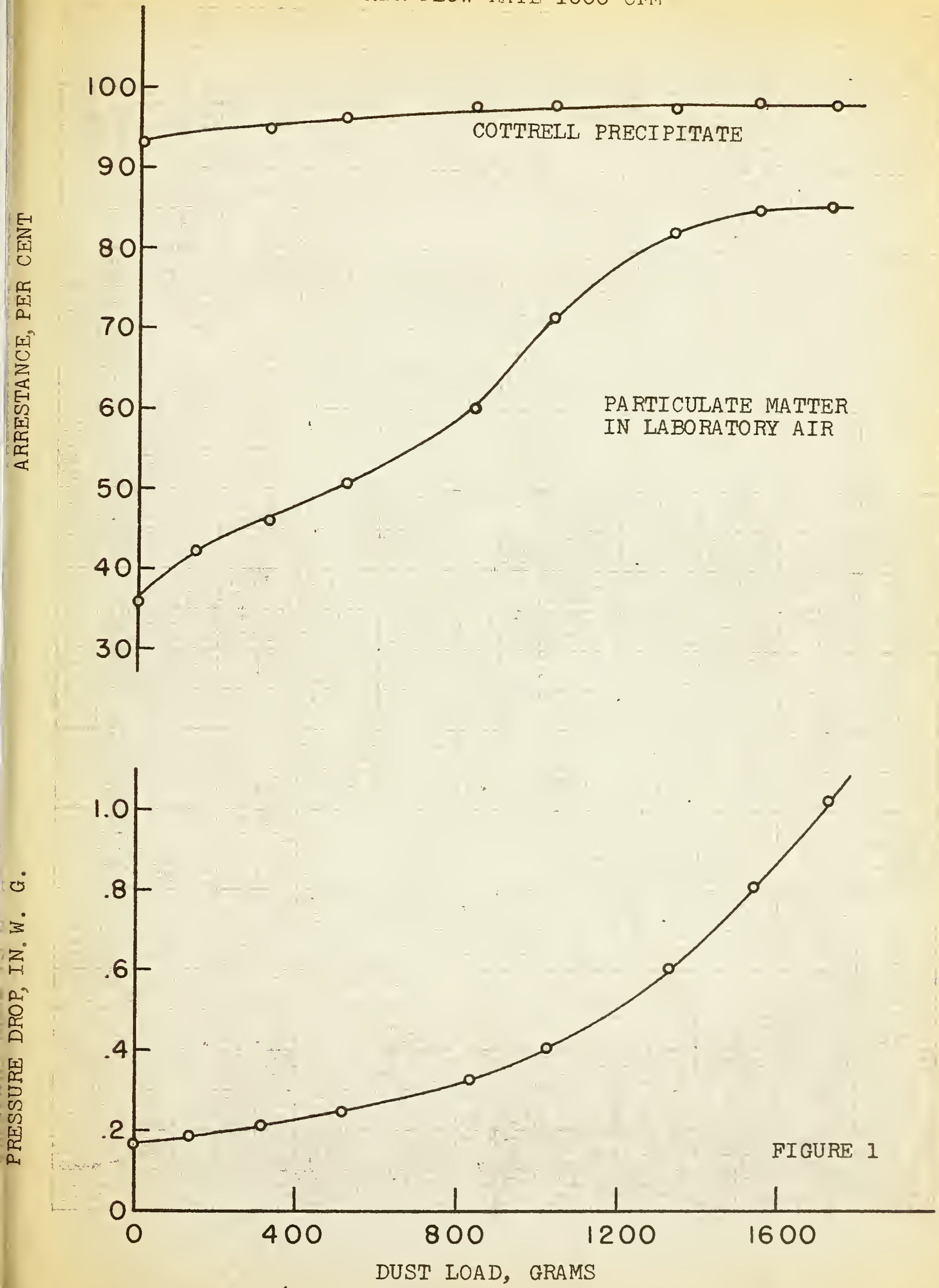

FIGURE 1

THE NATIONAL BUREAU OF STANDARDS

The scope of activities of the National Bureau of Standards at its major laboratories in Washington, D.C., and Boulder, Colorado, is suggested in the following listing of the divisions and sections engaged in technical work. In general, each section carries out specialized research, development, and engineering in the field indicated by its title. A brief description of the activities, and of the resultant publications, appears on the inside of the front cover.

WASHINGTON, D. C.

Electricity. Resistance and Reactance. Electrochemistry. Electrical Instruments. Magnetic Measurements. Dielectrics. High Voltage. Absolute Electrical Measurements.

Metrology. Photometry and Colorimetry. Refractometry. Photographic Research. Length. Engineering Metrology. Mass and Volume.

Heat. Temperature Physics. Heat Measurements. Cryogenic Physics. Equation of State. Statistical Physics.

Radiation Physics. X-ray. Radioactivity. Radiation Theory. High Energy Radiation. Radiological Equipment. Nucleonic Instrumentation. Neutron Physics.

Analytical and Inorganic Chemistry. Pure Substances. Spectrochemistry. Solution Chemistry. Standard Reference Materials. Applied Analytical Research. Crystal Chemistry.

Mechanics. Sound. Pressure and Vacuum. Fluid Mechanics. Engineering Mechanics. Rheology. Combustion Controls.

Polymers. Macromolecules: Synthesis and Structure. Polymer Chemistry. Polymer Physics. Polymer Characterization. Polymer Evaluation and Testing. Applied Polymer Standards and Research. Dental Research.

Metallurgy. Engineering Metallurgy. Metal Reactions. Metal Physics. Electrolysis and Metal Deposition.

Inorganic Solids. Engineering Ceramics. Glass. Solid State Chemistry. Crystal Growth. Physical Properties. Crystallography.

Building Research. Structural Engineering. Fire Research. Mechanical Systems. Organic Building Materials. Codes and Safety Standards. Heat Transfer. Inorganic Building Materials. Metallic Building Materials.

Applied Mathematics. Numerical Analysis. Computation. Statistical Engineering. Mathematical Physics. Operations Research.

Data Processing Systems. Components and Techniques. Computer Technology. Measurements Automation. Engineering Applications. Systems Analysis.

Atomic Physics. Spectroscopy. Infrared Spectroscopy. Far Ultraviolet Physics. Solid State Physics. Electron Physics. Atomic Physics. Plasma Spectroscopy.

Instrumentation. Engineering Electronics. Electron Devices. Electronic Instrumentation. Mechanical Instruments. Basic Instrumentation.

Physical Chemistry. Thermochemistry. Surface Chemistry. Organic Chemistry. Molecular Spectroscopy. Elementary Processes. Mass Spectrometry. Photochemistry and Radiation Chemistry.

Office of Weights and Measures.

BOULDER, COLO.

CRYOGENIC ENGINEERING LABORATORY

Cryogenic Processes. Cryogenic Properties of Solids. Cryogenic Technical Services. Properties of Cryogenic Fluids.

CENTRAL RADIO PROPAGATION LABORATORY

Ionosphere Research and Propagation. Low Frequency and Very Low Frequency Research. Ionosphere Research. Prediction Services. Sun-Earth Relationships. Field Engineering. Radio Warning Services. Vertical Soundings Research.

Troposphere and Space Telecommunications. Data Reduction Instrumentation. Radio Noise. Tropospheric Measurements. Tropospheric Analysis. Spectrum Utilization Research. Radio-Meteorology. Lower Atmosphere Physics.

Radio Systems. Applied Electromagnetic Theory. High Frequency and Very High Frequency Research. Frequency Utilization. Modulation Research. Antenna Research. Radiodetermination.

Upper Atmosphere and Space Physics. Upper Atmosphere and Plasma Physics. High Latitude Ionosphere Physics. Ionosphere and Exosphere Scatter. Airglow and Aurora. Ionospheric Radio Astronomy.

RADIO STANDARDS LABORATORY

Radio Standards Physics. Frequency and Time Disseminations. Radio and Microwave Materials. Atomic Frequency and Time-Interval Standards. Radio Plasma. Microwave Physics.

Radio Standards Engineering. High Frequency Electrical Standards. High Frequency Calibration Services. High Frequency Impedance Standards. Microwave Calibration Services. Microwave Circuit Standards. Low Frequency Calibration Services.

Joint Institute for Laboratory Astrophysics - NBS Group (Univ. of Colo.).

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